

# ERS Updates U.S. Foodborne Disease Costs for Seven Pathogens

Jean C. Buzby and Tanya Roberts  
(202) 219-0905 (202) 219-0857

**P**athogens are disease-causing microorganisms that include bacteria, fungi, parasites, and viruses. Pathogens can cause illness through contaminated food, contaminated water, or person-to-person contact. Most foodborne illnesses typically have a rapid onset and are self-limiting. Common symptoms are gastrointestinal problems and vomiting. Foodborne illnesses range from mild to severe; some of the more severe cases can result in premature death.

U.S. Food and Drug Administration (FDA) researchers estimate that 1 to 3 percent of all foodborne-illness cases later develop secondary illnesses or complications that can occur in any part of the body, including the nerves, joints, and heart. These complications may be chronic and may cause premature death. For example, Guillain-Barré syndrome, a major cause of nontrauma neuromuscular paralysis in the United States, may follow a small percentage of *Campylobacter* infections. In rare cases, *Salmonella*, like many other bacterial and parasitic infections, can cause chronic disease syndromes, such as arthritis and meningitis. Societal costs have not been estimated for the vast majority of

complications associated with foodborne illnesses.

Each year, seven foodborne pathogens—*Campylobacter jejuni*, *Clostridium perfringens*, *E. coli* O157:H7, *Listeria monocytogenes*, *Salmonella*, *Staphylococcus aureus*, and *Toxoplasma gondii* (see box on seven foodborne illnesses)—cause an estimated 3.3 million to 12.3 million cases of foodborne illness in the United States and up to 3,900 deaths. Last year, USDA's Economic Research Service (ERS) estimated that these seven foodborne illnesses cost society \$5.6 billion to \$9.4 billion (in 1993 dollars) in medical charges and lost productivity. Knowledge on the extent and severity of these illnesses is still growing, and estimates need to be updated as better data become available. This article updates those 1993 cost estimates and:

- Uses more recent data, where available, on annual foodborne-illness cases and deaths;
- Uses 1995 medical costs and wage rates; and
- Improves the consistency of calculations across all pathogens.

Researchers at the Centers for Disease Control and Prevention (CDC) estimate that listeriosis cases have fallen by 44 percent in the last decade because of educational, industry, and regulatory efforts to re-

duce *Listeria* contamination of foods and subsequent illnesses. The lower bound estimate reflects the decrease in listeriosis cases (table 1). The true number of annual listeriosis cases and deaths is still underestimated because only hospitalized cases are included, due to data limitations. Campylobacteriosis cases are also reported as a range to reflect uncertainty in the estimates, which is similar to other diseases in this analysis. The death rate for *S. aureus* intoxications was decreased from 0.08 percent to 0.03 percent on the advice of CDC researchers. The range of 800-4,000 salmonellosis deaths was also replaced by updated estimates of 1,000-2,000 deaths.

This update also includes a second set of cost-of-illness estimates that use less conservative values of a statistical life (a generic monetary value for an unidentified individual) as a proxy for the societal costs of someone who dies prematurely or who is unable to work because of a foodborne illness.

## Calculating the Costs of Foodborne Illness

The cost-of-illness estimates are calculated from the number of annual foodborne-illness cases and deaths caused by the seven foodborne illnesses described in this arti-

The authors are economists with the Food and Consumer Economics Division, Economic Research Service, USDA.

## Study Considers Seven Foodborne Illnesses

### *Campylobacter jejuni*

**Campylobacteriosis** ranges from a mild illness with diarrhea lasting a day, to severe abdominal pain, severe diarrhea (sometimes bloody), sometimes accompanied by fever, occasionally lasting for several weeks. The incubation period for most cases is 2 to 5 days, and the illness usually lasts from 2 to 10 days, depending on its severity. Although the illness is generally regarded as a relatively mild disease, death can occur in some cases, especially for the very young, very old, or immunocompromised.

### *Clostridium perfringens*

**C. perfringens intoxication** typically occurs 6 to 24 hours after ingestion of food that bears large counts of this bacteria. The illness in humans is frequently a mild gastrointestinal distress, lasting only around a day. Deaths are uncommon.

### *Escherichia coli* O157:H7

**E. coli O157:H7 disease** usually a mild gastrointestinal illness that occurs 3 to 5 days after eating contaminated food. Severe complications, however, can arise. Hemorrhagic colitis is distinguished by the sudden onset of severe abdominal cramps, little or no fever, and diarrhea that may become grossly bloody. Although less than 5 percent of *E. coli*

O157:H7 disease cases develop hemolytic uremic syndrome (HUS), it is a severe, life-threatening illness. HUS is a disease characterized by red blood-cell destruction, kidney failure, and neurological complications, such as seizures and strokes. Most HUS cases are children under 5 years old, although the feeble elderly may also be at risk.

### *Listeria monocytogenes*

**Listeriosis** may be either mild or severe. Milder cases are characterized by a sudden onset of fever, severe headache, vomiting, and other influenza-type symptoms. Listeriosis may appear mild in healthy adults and more severe in fetuses, the elderly, and the immunocompromised. Outbreak data show that the incubation period ranges from 3 to 70 days. Women infected with *Listeria* during pregnancy may transmit the infection to the fetus, possibly leading to stillbirths or babies born with mental retardation.

### *Salmonella*

**Salmonellosis** usually appears 6 to 74 hours after eating contaminated food and lasts for a day or two. Common symptoms are nausea, diarrhea, stomach pain, and sometimes vomiting. Although the illness is generally regarded as a relatively mild disease, death can occur in

some cases, especially for the very young, very old, or immunocompromised.

### *Staphylococcus aureus*

**S. aureus intoxication** usually occurs within 1 to 6 hours following consumption of the toxins produced by the bacteria, but it may occur within 30 minutes. Illness caused by *S. aureus* enterotoxin is characterized by severe nausea, vomiting, cramps, and diarrhea. Although the illness generally does not last longer than 1 or 2 days, the severity of the illness may indicate the need for hospitalization.

### *Toxoplasma gondii*

**Toxoplasmosis** can cause mild flu-like symptoms, though most people infected with the parasite do not have any symptoms. People vary in their risk of getting sick from this parasite. People with suppressed immune systems, such as AIDS and cancer patients, face higher risks. One outbreak associated with undercooked meat indicates that the incubation period ranges from 10 to 23 days. Women infected with *T. gondii* during pregnancy may transmit the infection to their fetus, possibly leading to stillbirths or babies born with birth defects ranging from hearing or visual impairments to mental retardation.

cle; the number of cases that develop secondary complications; and the corresponding medical costs, lost productivity costs, and other illness-specific costs, such as special education and residential-care costs (table 2).

In general, for each foodborne illness, cases were divided into four severity groups: those who did not visit a physician, those who visited a

physician, those who were hospitalized, and those who died prematurely because of their illness. For each severity group, medical costs were estimated for physician and hospital services, supplies, medications, and special procedures unique to treating the particular foodborne illnesses. Such costs reflect the number of days/treatments of a medical service, the average cost per service, and the number of patients receiving such service.

Most people with foodborne illnesses miss a day or so of work. This lost productivity is approximated by wage rates, published by the Bureau of Labor Statistics. However, some patients die and some develop complications so that they either never return to work, regain only a portion of their pre-illness productivity, or switch to less demanding and lower paying jobs. The total cost of lost productivity is the

sum for all individuals affected, including the patients and, in the case of ill children, their parents or paid caregivers.

## Calculating the Value of a Statistical Life

ERS now uses two different approaches to estimate the value of a

statistical life (see box). The first approach estimates the value of a statistical life by using records indicating consumers' willingness to pay to reduce the risks of death and poor health. The hedonic-wage approach uses labor market data to estimate consumers' willingness to pay. Consumers, often subconsciously, place a value on life and health when they

earn higher wages in jobs that incur risks. Typically, employers must offer workers higher wages to induce them to take such a job, as opposed to similar jobs with no such risks.

W. Kip Viscusi, an economist with Duke University, compared wage differences in 24 wage-risk studies and found that the extra wages asso-

Table 1  
**Not All Illnesses and Deaths From These Pathogens Are From Food Sources**

| Pathogen and disease/complication                                     | Estimated total annual cases | Estimated total annual deaths | Estimated share foodborne |
|---|------------------------------|-------------------------------|---------------------------|
|   | Number                       | Number                        | Percent                   |
| <b>Bacteria:</b>  |                              |                               |                           |
| <i>Campylobacter jejuni</i> or <i>coli</i><br>Campylobacteriosis      | 2,000,000-10,000,000         | 200-730                       | 55-70                     |
| <i>Clostridium perfringens</i><br><i>C. perfringens</i> intoxications | 10,000                       | 100                           | 100                       |
| <i>Escherichia coli</i> O157:H7<br><i>E. coli</i> O157:H7 disease     | 10,000-20,000                | 100-250                       | 80                        |
| Hemolytic uremic syndrome <sup>1</sup>                                | 400-820                      | 120-291                       | 80                        |
| Subtotal  | N/A                          | 220-541                       | N/A                       |
| <i>Listeria monocytogenes</i> <sup>2</sup><br>Listeriosis             | 1,092-1,860                  | 270-510                       | 85-95                     |
| Complications   | 26-43                        | 0                             | 85-95                     |
| Subtotal  | N/A                          | 270-510                       | N/A                       |
| <i>Salmonella</i> (non-typhoid)<br>Salmonellosis                      | 800,000-4,000,000            | 1,000-2,000                   | 87-96                     |
| <i>Staphylococcus aureus</i><br><i>S. aureus</i> intoxications        | 8,900,000                    | 2,670                         | 17                        |
| <b>Parasite:</b>  |                              |                               |                           |
| <i>Toxoplasma gondii</i> <sup>3</sup><br>Toxoplasmosis                | 435                          | 79                            | 50                        |
| Complications   | 3,083                        | 0                             | 50                        |
| Subtotal  | 3,162                        | 79                            | N/A                       |
| <b>Total<sup>4</sup></b>  | 11,700,000-22,900,000        | 4,500-6,600                   | N/A                       |

Notes: N/A = Not applicable. <sup>1</sup>Kidney failure. <sup>2</sup>Includes only hospitalized patients because of data limitations. <sup>3</sup>Includes only toxoplasmosis cases related to fetuses and newborn children who may become blind or mentally retarded. 435 develop severe acute illness at birth, of which 79 die and 356 survive acute illness but develop complications by age 17. In addition to these 356 acute cases with complications, 2,727 cases do not have noticeable acute illness at birth but develop complications by age 17 for a total of 3,083 with complications. Does not include all other cases of toxoplasmosis. Another high-risk group for this parasite is the immunocompromised, such as patients with AIDS. <sup>4</sup>Totals are rounded down to reflect the uncertainty of the estimates.

ciated with the increased overall hazard of one death from risky jobs are between \$3 million and \$7 million (in 1990 dollars). Several regulatory agencies use either Viscusi's range of estimates or the \$5 million midpoint when analyzing the bene-

fits of proposed public-safety rules. The \$5 million midpoint value for a statistical life estimate was used for the cost estimates in table 2.

The second approach to estimate the value of a statistical life focuses primarily on lost productivity. For

those who die or are unable to return to work, this lost productivity is calculated using a combination of human-capital and willingness-to-pay estimates developed by J. Steven Landefeld and Eugene Seskin of the U.S. Department of Com-

Table 2

### *Toxoplasma gondii*, *Campylobacter*, and *Salmonella* Are the Most Costly Foodborne Pathogens<sup>1</sup>

| Pathogen and disease/complication                                     | Estimated foodborne illness—<br>CasesDeaths |             | Estimated foodborne illness costs, assuming—<br>\$5 million per life <sup>2</sup> Landefeld & Seskin <sup>3</sup> |          |
|---|---|-------------|---|----------|
|   | Number                                      |             | Billion dollars   |          |
| <b>Bacteria:</b>  |   |             |   |          |
| <i>Campylobacter jejuni</i> or <i>coli</i><br>Campylobacteriosis      | 1,100,000-7,000,000                         | 110-511     | 1.2-6.6   | .7-4.3   |
| <i>Clostridium perfringens</i><br><i>C. perfringens</i> intoxications | 10,000                                      | 100         | .5  | .1       |
| <i>Escherichia coli</i> O157:H7<br><i>E. coli</i> O157:H7 disease     | 8,000-16,000                                | 80-200      | .4-1.0  | .1-.3    |
| Hemolytic uremic syndrome <sup>4</sup>                                | 320-656                                     | 96-233      | .5-1.2  | .2-.4    |
| Subtotal  | N/A   | 176-433     | .9-2.2  | .3-.7    |
| <i>Listeria monocytogenes</i> <sup>5</sup><br>Listeriosis             | 928-1,767                                   | 230-485     | 1.2-2.2   | .12-.25  |
| Complications   | 22-41                                       | 0           | .1-.2   | .03-.05  |
| Subtotal  | N/A   | 230-485     | 1.3-2.4   | .1-.3    |
| <i>Salmonella</i> (non-typhoid)<br>Salmonellosis                      | 696,000-3,840,000                           | 870-1,920   | 4.8-12.2  | .9-3.5   |
| <i>Staphylococcus aureus</i><br><i>S. aureus</i> intoxications        | 1,513,000                                   | 454         | 3.3   | 1.2      |
| <b>Parasite:</b>  |   |             |   |          |
| <i>Toxoplasma gondii</i> <sup>6</sup><br>Toxoplasmosis                | 217   | 40          | .1  | .04      |
| Complications   | 1,541                                       | 0           | 7.6   | 3.15     |
| Subtotal  | 1,581                                       | 40          | 7.7   | 3.2      |
| <b>Total</b> <sup>7</sup>   | 3,300,000-12,300,000                        | 1,900-3,900 | 19.7-34.9   | 6.5-13.3 |

Notes: N/A = Not applicable. <sup>1</sup>Cost estimates are in 1995 dollars. <sup>2</sup>The \$5 million value of a statistical life was estimated from wage-risk studies. <sup>3</sup>This human-capital approach, increased by a willingness-to-pay multiplier, estimates the value of a statistical life, depending on age, to range from roughly \$15,000 to \$1,979,000 in 1995 dollars. <sup>4</sup>Kidney failure. <sup>5</sup>Includes only hospitalized patients because of data limitations. <sup>6</sup>Includes only toxoplasmosis cases related to fetuses and newborn children who may become blind or mentally retarded. 217 cases develop severe acute illness at birth, of which 40 die and 177 survive acute illness but develop complications by age 17. In addition to these 177 acute cases with complications, 1,364 cases do not have noticeable acute illness at birth but develop complications by age 17 for a total of 1,541 foodborne illness cases with complications. Does not include all other cases of toxoplasmosis. Another high-risk group for this parasite is the immunocompromised, such as patients with AIDS. <sup>7</sup>Totals are rounded down to reflect the uncertainty of the estimates.

## Estimating the Value of a Statistical Life

### Hedonic-wage approach:

- Estimated from hedonic-wage studies, which use labor market data on how much employers must offer workers, in terms of higher wages, to induce workers to take a job with some injury risks, as opposed to a similar job with no such risks.
- Estimated value of saving a life is \$5 million for each life in 1995 dollars, regardless of age.
- These studies produce more usable estimates for mortality risks than they do for risks of temporary or chronic illnesses.

The hedonic-wage approach most likely excludes government and industry costs as well as other costs that individuals may not consider when deciding to accept a risky job.

### Landefeld and Seskin's human capital/willingness-to-pay (WTP) approach:

- Generates the present value of expected lifetime after-tax income and housekeeping services at a 3-percent real rate of return, adjusted for an annual 1-percent increase in labor productivity and a risk-aversion factor of 1.6. The

risk-aversion factor is based on the ratio of life-insurance premium payments to life-insurance loss payments. In most cases, life insurance premiums represent "household WTP for potential losses associated with the death of an income-earning household member."

- Estimates the value of a statistical life, depending on age, to range from roughly \$15,000 to \$1,979,000 in 1995 dollars.

This more conservative approach underestimates the true costs of foodborne illnesses to society because it excludes costs, such as:

- Pain, suffering, and lost leisure time of the patient and family;
- Lost business and costs and liabilities of lawsuits affecting agriculture and the food industry;
- The value of self-protective behaviors undertaken by industry and consumers;
- Resources spent by Federal, State, and local governments to investigate the source and epidemiology of the outbreak; and
- The value of reducing risks for people who do not become ill.

## High Costs of Foodborne Illness

When Landefeld and Seskin's value of a statistical life estimates were used in the cost-of-illness analyses, total annual costs of the seven foodborne illnesses ranged between \$6.5 and \$13.3 billion. Using the \$5 million value of a statistical life estimate from the hedonic-wage studies, total annual costs ranged between \$19.7 and \$34.9 billion.

Both sets of estimates undervalue the true costs of foodborne illnesses to society, however, because the analyses covered only seven pathogens—there are over 40 different foodborne pathogens believed to cause human illnesses. Estimated costs would also increase if the costs for all complications linked to foodborne illnesses, such as arthritis, meningitis, or Guillain-Barré syndrome, were included. Costs would increase even further if monetary value were placed on public-safety risk reductions for those who do not become ill.

## Government Efforts Improve Food Safety

FDA, CDC, and USDA's Food Safety and Inspection Service (FSIS) are currently collaborating on an active surveillance project to improve estimates of the pathogens responsible for diarrheal disease and to identify risk factors that increase or decrease the chances of becoming ill. Better information can be used to improve the design of control programs. *Salmonella* and *Escherichia coli* O157:H7 (*E. coli* O157:H7) will be the first target, followed by additional pathogens as the study expands.

FSIS's Hazard Analysis and Critical Control Point (HACCP) final rule was released in July 1996 to enhance the safety of meat and poultry.

merce. Human-capital estimates are the value in today's dollars of an individual's lifetime stream of income if the illness had not occurred. The human-capital estimates are increased by a multiplier that captures people's willingness to pay to avoid death, as reflected in life insurance premiums. These estimates of the value of a statistical life range, depending on age, from roughly \$15,000 to \$1,979,000 (in 1995 dollars). The major limitation of this approach is that it does not fully consider the value that individuals may place on (and pay for) feeling

healthy, avoiding pain and suffering, or using their free time. Because the approach does not cover all of these valuable aspects of health, the approach is generally thought to understate the true societal costs.

ERS uses both approaches here because economists have not reached a consensus on which estimates to use, though they may now be leaning toward the hedonic-wage approach. Previously, ERS used the Landefeld and Seskin estimates in cost-of-illness analyses because these estimates are more conservative and provide values for patients of different ages, instead of one value for patients of all ages.



Under HACCP, all meat and poultry slaughtering and processing plants must examine their operations and identify the hazards and the specific points that pose the greatest food safety risks. To ensure control of physical, biological, or chemical hazards, the plants will then establish critical limits for preventive measures associated with each identified point. There are also steps for monitoring, recordkeeping, and verifying, which include some testing of meat and poultry for microbial contamination to ensure that the HACCP system is meeting safety targets. Both the plants and FSIS are responsible for verifying the effectiveness of HACCP.

FSIS's HACCP intervention will be phased in over a 3-year period, with larger plants expected to comply sooner than small plants. FDA promulgated a similar HACCP rule for seafood in December 1995. Both rules strengthen the ongoing efforts

of industry and Government to reduce the number of U.S. foodborne illness cases and deaths.

## References

Buzby, Jean C., and Tanya Roberts. "ERS Estimates Foodborne Disease Costs," *FoodReview*, USDA, Economic Research Service, Vol. 18, Issue 2, May-Aug. 1995, pp. 37-42.

Buzby, Jean C., Tanya Roberts, C.-T. Jordan Lin, and James M. MacDonald. *Bacterial Foodborne Disease: Medical Costs and Productivity Losses*, AER-741. USDA, Economic Research Service. Aug. 1996.

Council for Agricultural Science and Technology. *Foodborne Pathogens: Risks and Consequences*, Task Force Report No. 122. Washington, DC. Sept. 1994.

Landefeld, J. Steven, and Eugene P. Seskin. "The Economic Value of Life: Linking Theory to Practice," *American Journal of Public Health*, Vol. 6, 1982, pp. 555-66.

"Pathogen Reduction; Hazard Analysis and Critical Control Point (HACCP) Systems, Final Rule," *Federal Register*, Vol. 61, No. 144, July 25, 1996, pp. 38805-989.

"Preliminary Regulatory Impact Assessment for Docket No. 93-016P—Pathogen Reduction; Hazard Analysis and Critical Control Point (HACCP) Systems," *Federal Register*, Vol. 60, No. 23, Feb. 3, 1995, pp. 6774-889.

"Procedures for the Safe and Sanitary Processing and Importing of Fish and Fishery Products: Final Rule," *Federal Register*, Vol. 60, No. 242, Dec. 18, 1995, pp. 65095-200.

Viscusi, W.K. "The Value of Risks to Life and Health," *Journal of Economic Literature*, Vol. 31, Dec. 1993, pp. 1912-46. ■